TiO$_2$ Nanotube Array Based Photoelectrochemical Water Splitting

Peng Wang and Zhonghai Zhang
Water Desalination and Reuse Center, Biological and Environmental Science and Engineering Division, King Abdullah University of Science and Technology, Thuwal 23955-6900, Saudi Arabia
*peng.wang@kaust.edu.sa;
website: http://faculty.kaust.edu.sa/sites/pengwang

In this presentation, we show that by varying the voltages during two-step anodization the morphology of the hierarchical top-layer/bottom-tube arrays TiO$_2$ (TiO$_2$ NTs) can be finely tuned between nanoring/nanotube, nanopore/nanotube, and nanohole–nanocave/nanotube morphologies, which allows us to optimize the photoelectrochemical (PEC) water splitting performance on the hierarchical TiO$_2$ NTs. The optimized photocurrent density and photoconversion efficiency of the hierarchical TiO$_2$ NTs were 1.59 mA cm$^{-2}$ at 1.23 V vs. RHE and 0.84% respectively, which are the highest values ever reported on pristine TiO$_2$ materials under illumination of AM 1.5G. The top porous layer of the hierarchical TiO$_2$ NTs was found to have characteristics of photonic crystal, which was utilized to combine with plasmonic Au nanocrystals to produce visible-light active composite material. The selection of the Au nanocrystals is so that their surface plasmonic resonance (SPR) wavelength matches the photonic band gap of the photonic crystal and thus the SPR of the Au receives remarkable assistance from the photonic crystal substrate. Under visible light illumination (>420nm), the designed material produced a photocurrent density of ~150 µA cm$^{-2}$, which is the highest value ever reported in any plasmonic Au/TiO$_2$ system under visible light irradiation. Additionally, palladium nanocrystals were deposited onto the TiO$_2$ NTs (Pd/TiO$_2$ NTs) and, because of formation Schottky junctions between TiO$_2$ and Pd, the Pd/TiO$_2$ NTs showed significantly higher water contaminant decomposition activities than the TiO$_2$ NTs.

References: